The Mid and Far IR Universe, and Facilities to See It

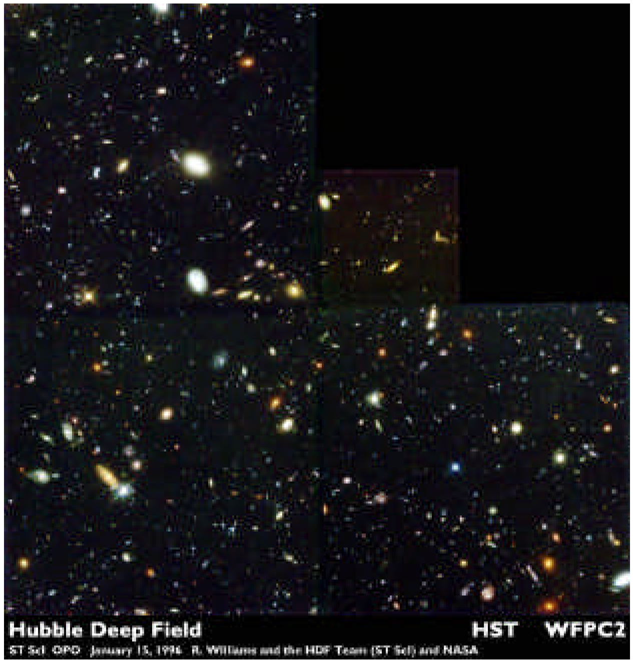
John Mather, NGST Study Scientist,
NASA GSFC, Greenbelt, MD 20771

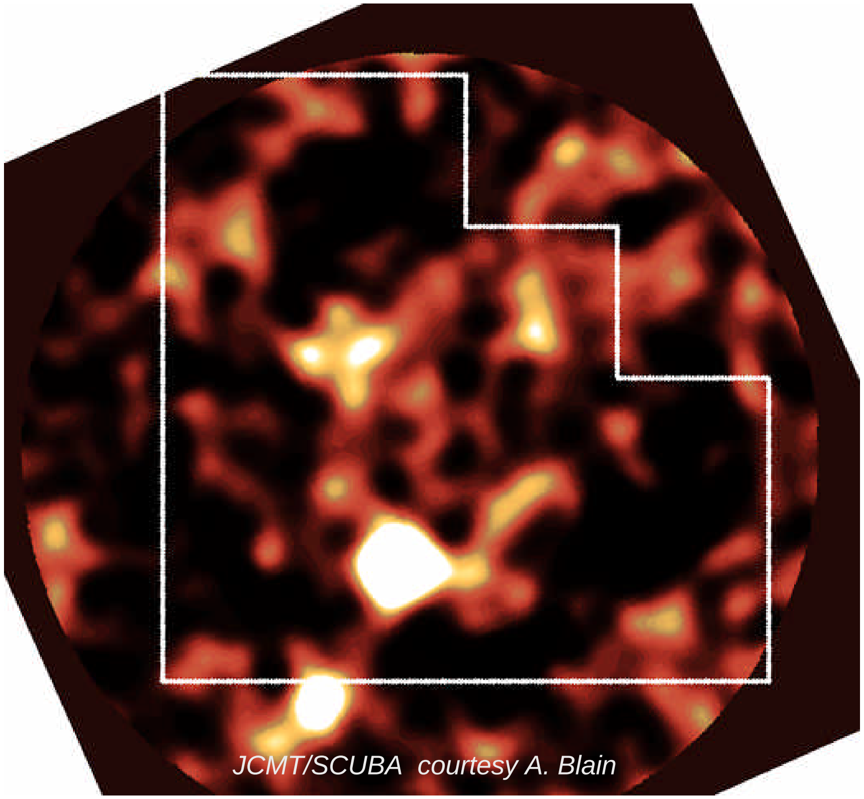
Talks in this Session

- Intro - Mather
- Cold large telescope - Rieke
- Galactic nuclei and bulges - Spergel
- Galaxy formation - Blain
- Star and Planet formation - Evans
- Far IR surveys - Moseley

Our present view of the Universe in the submillimeter, instead of looking

like this, looks like this



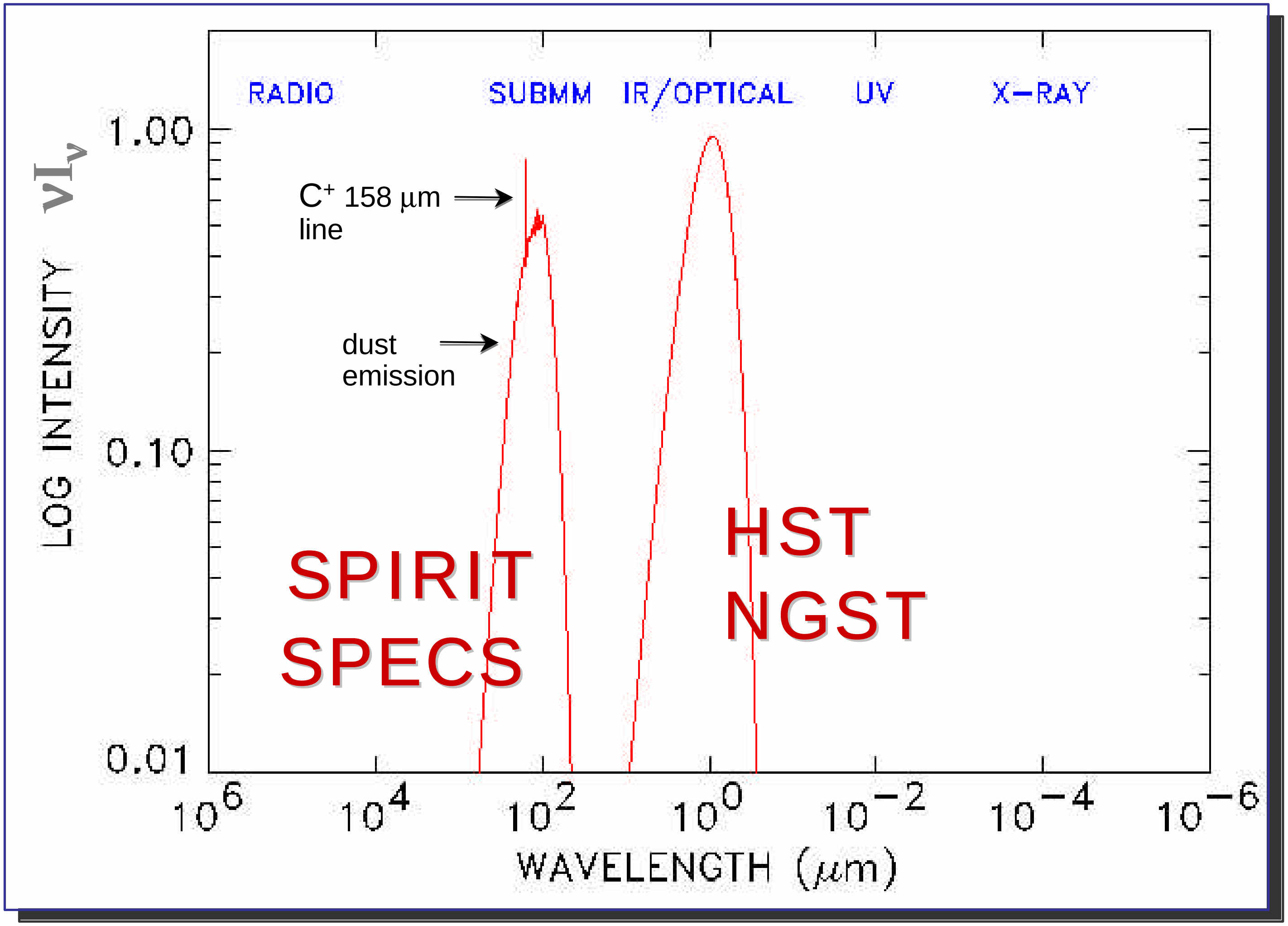


Open Scientific Questions

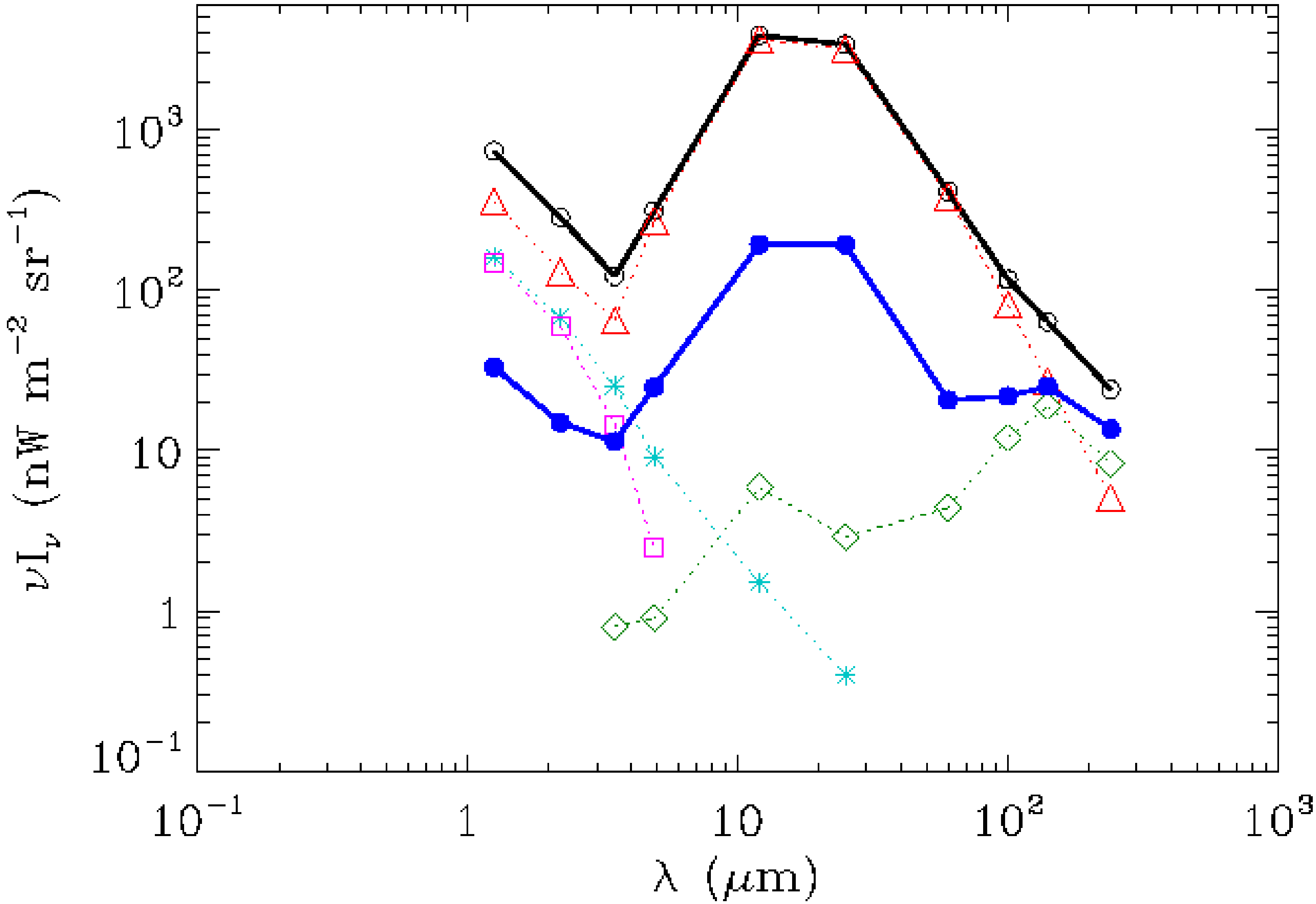
- What makes the far IR background? Starbursts, AGN, first generation superstars?
- Why is there a black hole in almost every galaxy, with mass proportional to the bulge mass?
- Why can’t we see the SCUBA sources at shorter wavelengths?
- What about the Chandra sources that can’t be seen with anything else?
- How do stars and planets form?
- How does the interstellar medium work? (chemistry, heat, motion)
- When and where could life begin?

Spectrum of the Milky Way

Half of the luminosity and 98% of the photons released since the Big Bang are in the far-infrared and submillimeter

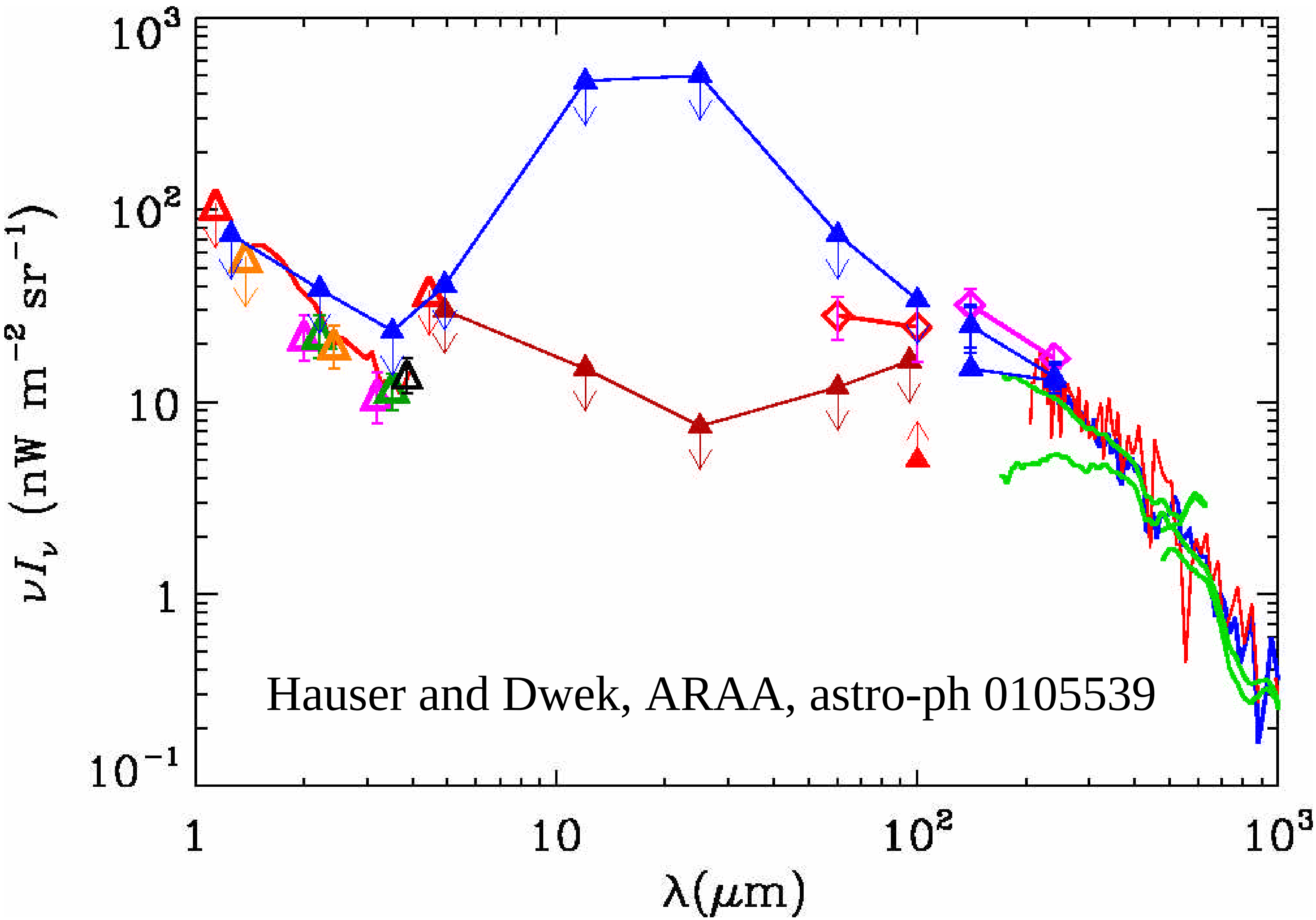


Measured IR Background Radiation

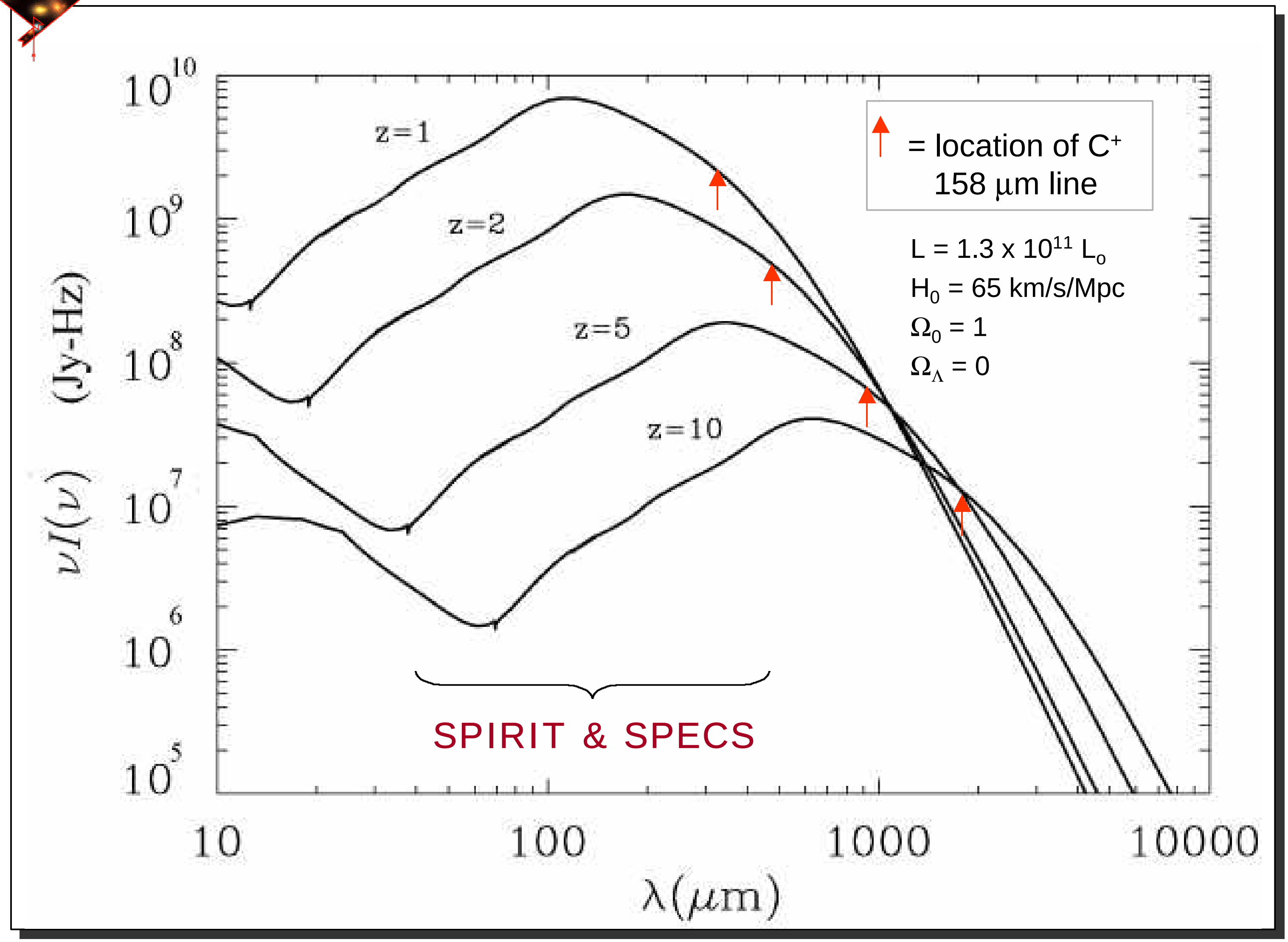


Hauser and Dwek ARAA, Fig 2

Cosmic Infrared Extragalactic Background Radiation



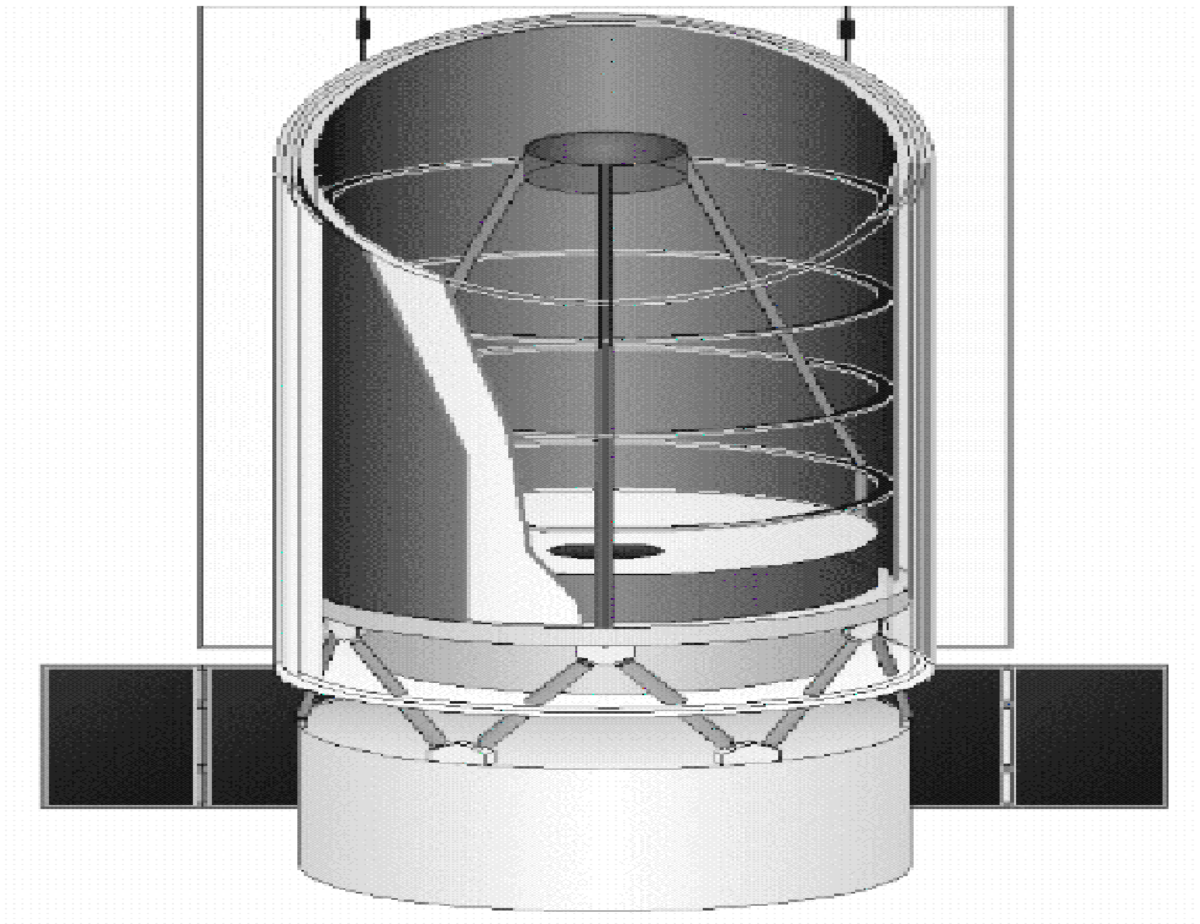
Starburst Galaxy Spectra



Next Generation Observatories

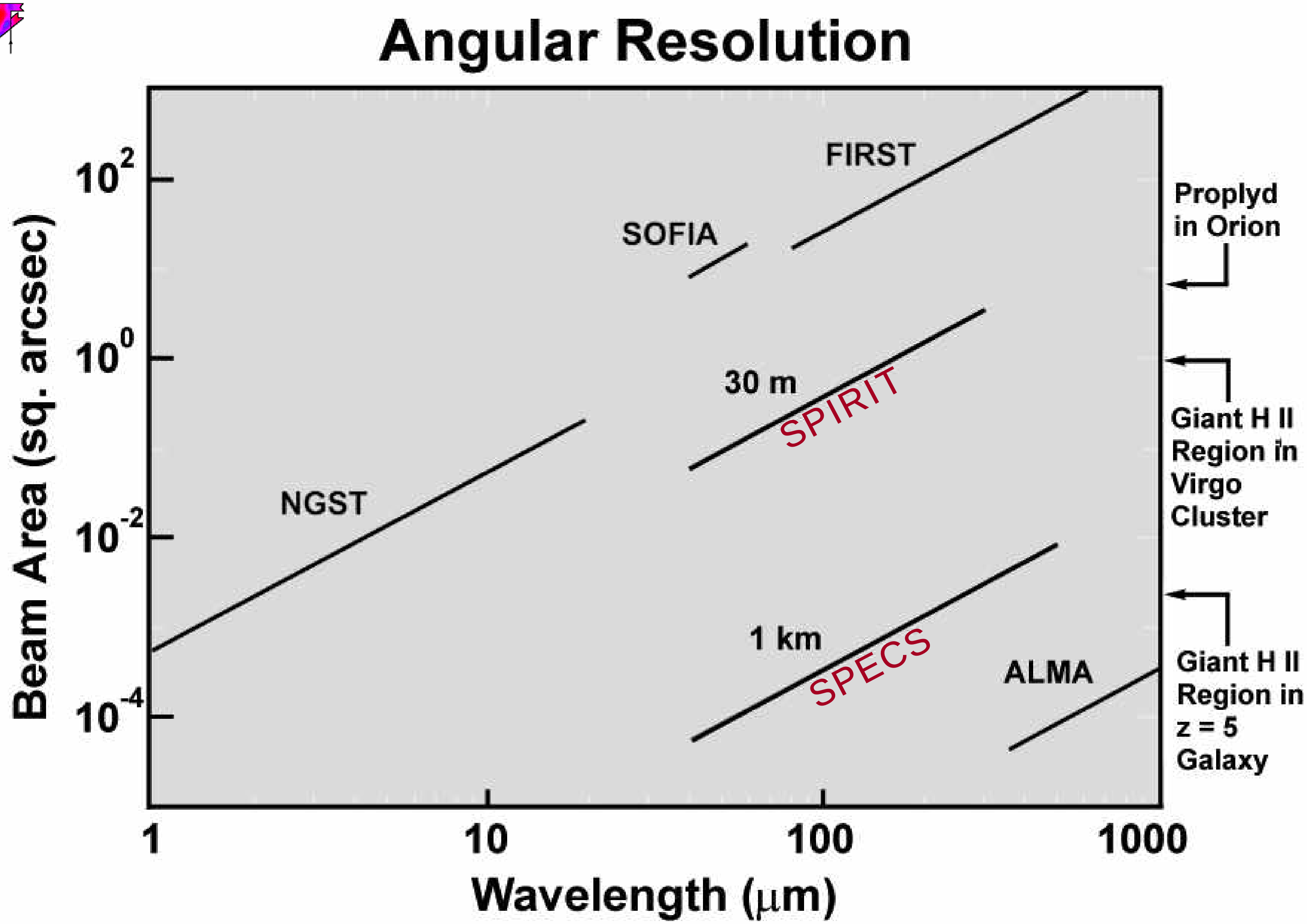
- After NGST could be FAIR/SAFIR (compare H2L2)
  - Endorsed for further study by the Decadal Survey
  - Colder version of NGST, ~ 8 m, $\lambda T < 600$ K - μm
  - Cameras, medium $R = \nu/\Delta\nu < 10^6/\lambda$ spectrometry
  - Compatible with coherent receivers for higher R
- After IRAS, COBE, Planck, 2MASS, and NGSS could be SIRCE
  - All sky far IR sky survey to confusion limit
- After ALMA could be SPIRIT/SPECS
  - Far IR cold interferometer (Fizeau or Michelson format, wide field, detector arrays, span 30 - 1000 m)
  - Beats confusion limit of single dish for $\lambda > 150$ μm
  - Alternative: larger, warmer single dish, with emphasis on high R spectroscopy, maybe coherent receivers

H2L2 Concept



Cold NGST Concept

SPIRIT and SPECS complement NGST and ALMA, providing virtually complete spectral coverage at high angular resolution



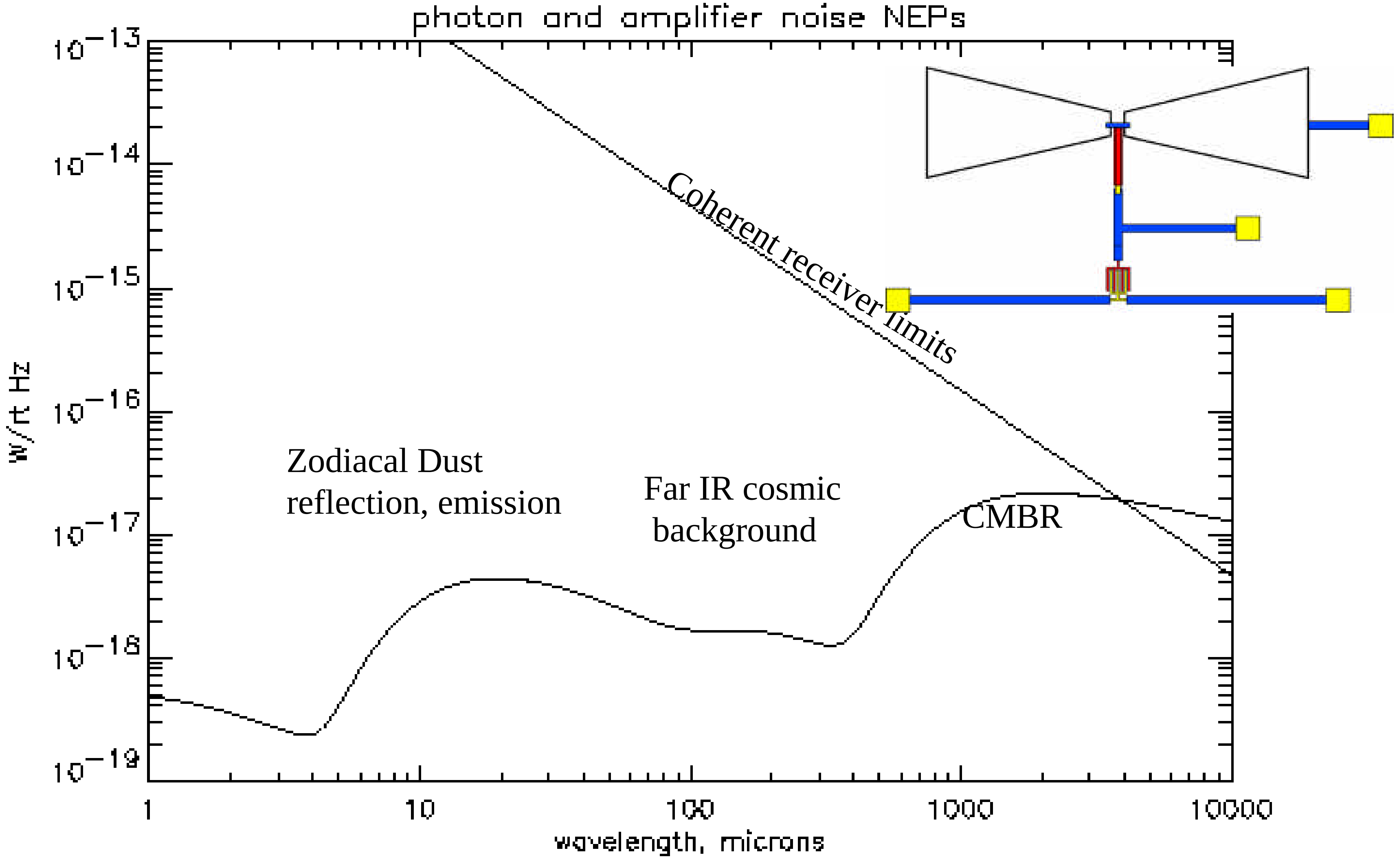
A 30 m baseline is needed to break through the confusion barrier and see individual high-z galaxies

A 1 km baseline is needed to resolve the young galaxies

Some Assembly Required

- New instrumentation - huge dispersive spectrometers, Fabry-Perot and Michelson interferometers, and combinations, testable on SOFIA
- Bigger, better detector arrays, amplifiers, and multiplexers, both photon and coherent
  - Entire system concept depends on these
  - Bolometers, superconducting tunnel junctions, photoconductors, SQUID amplifiers and multiplexers, single-electron transistors, etc.
  - Coherent receiver arrays, e.g. MMIC, with phased array capabilities to get efficient use of wide field
- Low power correlator arrays for coherent receivers and interferometers

Detector Photon Background Sensitivity Limits for 100% bandwidth (Δν=ν)



Systems Issues

- Deeper radiative and active cooling techniques for big dishes, interferometers, and detectors
- Tethered formation flying for long interferometers (SPECS)
- Bigger, lighter, colder mirrors than NGST
- Simulations, test facilities and procedures - what do you do after NGST and Plumbrook-class tanks?

When?

- Clearly long term programs, dependent on initial success in SIRTF, SOFIA, Planck, Herschel, NGST, H2L2, and ALMA (~ 1 - 12 years), and reaching their limits (15 - 20 years)
- Mid-Far IR science compelling in 20 years - there's no alternative to direct measurement
- Need robust detector technology program to push science visionaries - breakthroughs in 10 years
- Supporting technology also very difficult
  - May be developed by TPF